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How To

Identify, Prevent, and Control Oak Wilt

Forest Service
Northeastern Area
State & Private Forestry

NA–FR–01–11

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Pesticide Precautionary Statement

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Store pesticides in original containers under lock and key—out of the reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

Table of Contents

Introduction 1
Distribution 1
Hosts 2
How Infection Occurs: The Disease Cycle of Oak Wilt 5
  Local Spread of Oak Wilt 5
  Overland Spread of Oak Wilt 6
Symptoms 11
  Red Oak Group 11
  White Oak Group 12
  Texas Live Oak 12
Diagnosis 14
Other Disorders of Oaks 14
  Bacterial Leaf scorch 14
  Oak Anthracnose 14
  Oak Decline 15
  Twolined Chestnut Borer 16
Integrated Management of Oak Wilt 16
  Preventing New Infection Centers 16
    Remove Infected Trees 17
    Avoid Injuring Healthy Trees 17
  Controlling Existing Infection Centers . . . 18
    Trenching and Vibratory Plowing 19
    Stump Extraction as a Substitute for Trenching 22
    Chemical Root Disruption 22
  Chemical Control Using Fungicides 23
Summary of Integrated Oak Wilt Management Strategies 24
Literature Cited 26
Other References 26
Glossary 27
Northeastern Area State and Private Forestry Offices 30
Northern Research Station 30
Forest Service Southern Region State and Private Forestry Offices 31

Introduction

Oak wilt is an aggressive disease that affects many species of oak (*Quercus* spp.). It is one of the most serious tree diseases in the Eastern United States, killing thousands of oaks each year in forests, woodlots, and home landscapes.

Distribution

Oak wilt was first identified in 1944. The fungal pathogen that causes the disease, *Ceratocystis fagacearum*, is thought by most to be native to the Eastern United States, but difficulty in isolating and identifying the fungus delayed recognition of the extent of its impact until the 1980s. Recent evidence suggests that oak wilt is an exotic disease that arrived in North America in the early 1900s. However, the fungus has never been reported by any country other than the United States, so its origin remains unknown. The disease has also become much more apparent in some local areas since the 1980s because of increased tree wounding, due primarily to home construction in oak woods. The current known distribution of oak wilt is shown in red in figure 1.

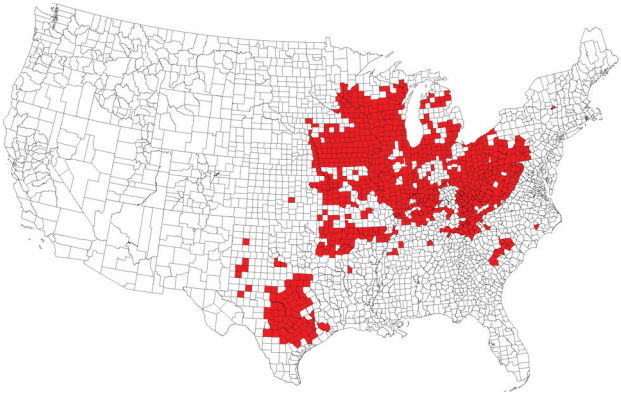

Figure 1.—In 2010, oak wilt was distributed over much of the Eastern United States.

Hosts

Oaks can be organized taxonomically into three main groups based on leaf shape and other characteristics: red oaks, white oaks, and live oaks. Trees in the red oak group have fan-shaped leaves with sharply pointed tips, those in the white oak group have fan-shaped leaves with rounded or blunt tips, and trees in the live oak group have oval leaves with pointed to rounded tips (figure 2). Oak species most commonly killed by the disease are listed in table 1.

All species in the white oak group are moderately resistant to oak wilt, but if infected, trees in this group can be killed over a period of one to several years. Resistance in white oaks appears to be related to their physiology and anatomy. If white oaks are wounded or infected, or as part of the natural aging process, they tend to form minute, balloon-like plugs called **tyloses** in their sapwood vessels. These plugs make the wood of white oaks impermeable to water, and also appear to prevent the fungus from moving throughout the vascular system of the tree.

The tendency for white oaks to form tyloses also explains why these are the species of choice for wood used in cooperage for storing wine and whiskey. The presence of tyloses ensures that barrels made from white oak wood will not leak.

Throughout the range of oak wilt in the United States, red oaks are the most important hosts. However, susceptibility varies somewhat by species. Mortality in red oaks can occur within 3 weeks after infection by the oak wilt pathogen under some circumstances. Recovery from oak wilt infections in red oaks can occur, but is rare. In Texas, live oak (*Q. virginiana*) is moderately susceptible to the disease, but because of its tendency to form large, root-connected clones through which the disease can spread, it is considered to be an important host and has sustained high levels of mortality.

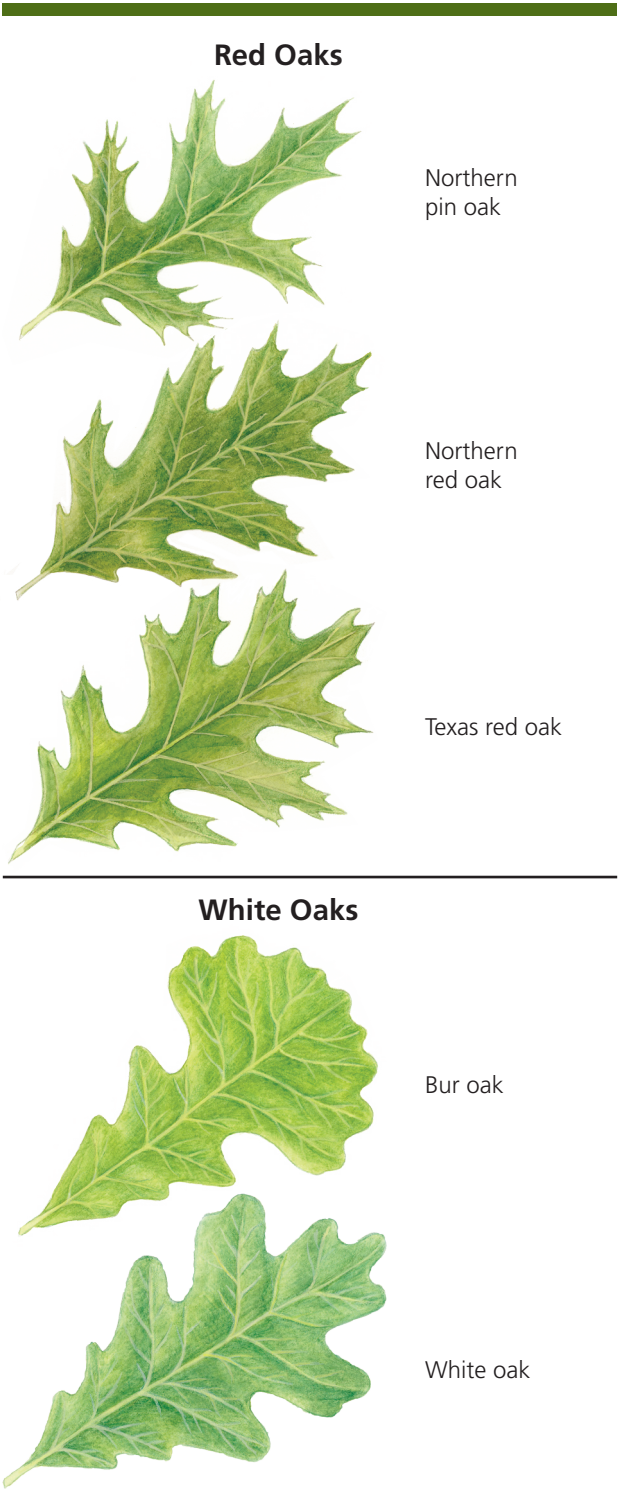

Figure 2.—The three main groups of oaks are organized by leaf shape.

Live Oaks

Texas live oak

Figure 2. Continued.—The three main groups of oaks are organized by leaf shape.

Although the disease is not known west of Texas, inoculation studies have shown that most oaks in the red oak group, including several western species, are susceptible to the disease and are at risk should the fungus ever be transmitted to them in their native habitat (Appel 1994).

Table 1. Oak species commonly killed by oak wilt.[1]

Common name(s)	Scientific name
Northern species	
Black oak	*Q. velutina*
Bur oak[2]	*Q. macrocarpa*
Northern pin oak	*Q. ellipsoidalis*
Northern red oak	*Q. rubra*
White oak[2]	*Q. alba*
Southern species	
Blackjack oak	*Q. marilandica*
Scrub live oak	*Q. fusiformis*
Shumard oak	*Q. shumardii*
Southern red oak	*Q. falcata*
Texas live oak	*Q. virginiana*
Texas red oak (Spanish oak)	*Q. buckleyi*

[1] All red oaks in the Eastern United States are considered susceptible to oak wilt.

[2] Infections are less common in these species and may take years to run their course.

How Infection Occurs: The Disease Cycle of Oak Wilt

The oak wilt fungus moves from tree to tree in two ways: underground through the roots or overland by insect **vectors**.

Local Spread of Oak Wilt

Most new tree infections occur when the fungus moves from an infected tree to a nearby healthy tree through connected root systems in a process called **local spread** (figure 3, lower pathway). The roots of trees in each oak group commonly graft to roots of other trees in the same group, forming a continuous underground network. When one tree in a group becomes infected and dies, the fungus spreads through the connected root systems, killing more trees and creating an **infection center**.

Root grafts do not commonly occur between trees of different oak species groups, although exceptions occur. Usually a mix of species in a given location will retard local spread and limit the impact of the disease. However, root grafts often do occur between Texas live oaks and red oaks in mixed stands.

Depending upon soil type and the mix of tree species in a forest or yard, infection of healthy trees through root grafts can occur at some distance (up to 100 feet or more) from an infected tree. Sandy soils are conducive to the formation of widespread root systems, increasing the likelihood of root grafts occurring farther away from a diseased tree. Some oak species, including northern pin oak and Texas live oak, often grow in large groups of similar-aged trees that share a common or clonal root system. Such situations can lead to rapid expansion of oak wilt centers if even one tree in the group becomes infected.

Overland Spread of Oak Wilt

New infection centers can occur if the fungus is carried from an infected tree to a fresh wound on a healthy tree by an insect in a process called **overland spread** (figure 3, upper pathway).

Under certain moisture and temperature conditions, compact masses of fungal material that produce spores—variously called **fungal mats**, **spore mats**, **spore pads**, or **pressure pads**—sometimes form on oak trees that have been killed by oak wilt (figure 4). These mats form just under the bark and are in contact with both the bark and the infected sapwood of the tree. As the mats mature, they produce specialized, non-spore-producing structures that exert outward pressure on the bark (the "pressure pads") and cause it to split, thus providing a route for insects to reach the mats (figure 5).

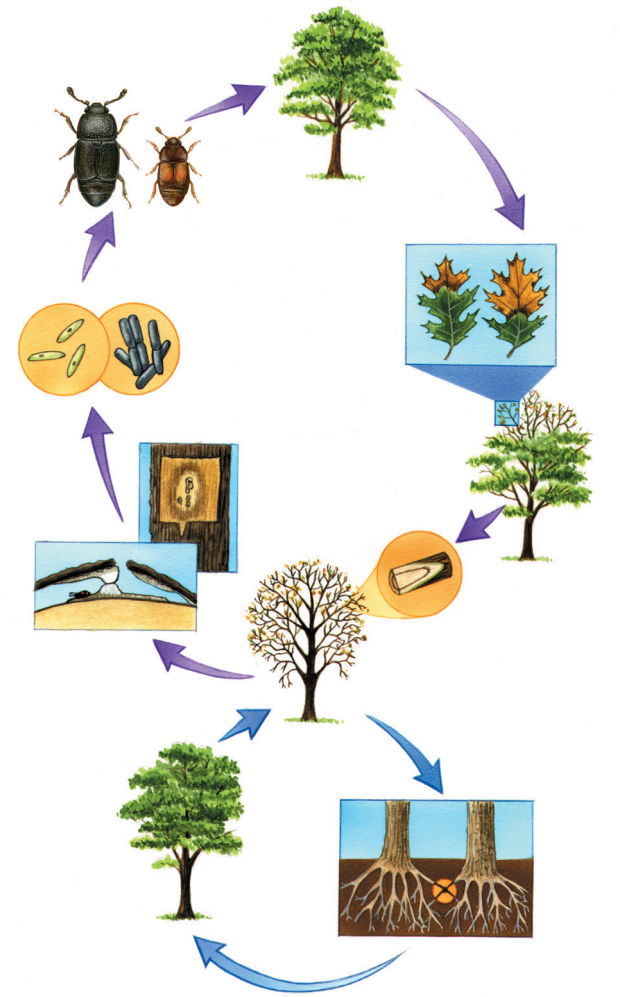

Figure 3.—The disease cycle of oak wilt.

Figure 3, upper pathway.—Long-distance spread of oak wilt occurs when nitidulid beetles carry spores of the fungus from spore mats on infected trees to wounds on healthy trees, causing infection and death of the tree. Time from infection to mortality may be very short for red oaks and Texas live oak, or many years for members of the white oak group.

Figure 3, lower pathway.—Local spread of oak wilt occurs when the fungus travels through the interconnected roots of infected and healthy trees.

Figure 4.—An oak wilt spore mat with pressure pads (arrow).

Figure 5.—Bark split caused by a pressure pad of the oak wilt fungus.

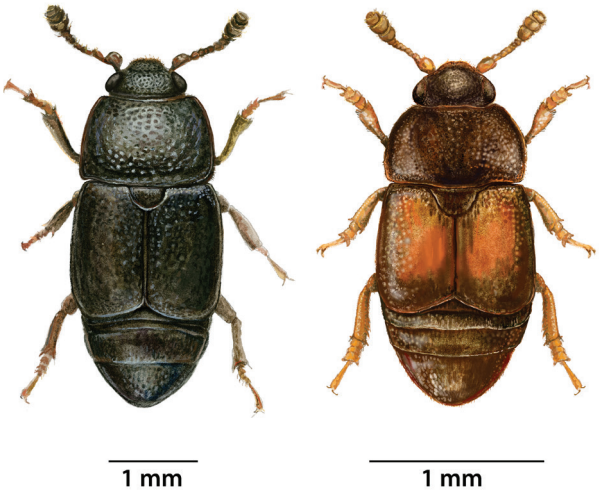

Figure 6.—Nitidulid beetles are primarily responsible for overland spread of oak wilt.

Oak wilt spore mats emit a strong, fruity or wine-like odor that attracts many different species of **nitidulid beetles** (figure 6), also known as sap beetles. As they feed on or tunnel through the spore mats, nitidulid beetles often accumulate fungal spores on the surface of their bodies.

Oak trees often sustain wounds caused by construction equipment, storms, pruning tools, or vandalism. Fresh wounds usually leak sap that attracts insects, including nitidulid beetles that have visited oak wilt spore mats. The overland movement of the fungus via nitidulid beetles that visit both spore mats on infected trees and wounds on otherwise healthy trees thus creates most new infection centers.

Not all nitidulid beetles are vectors of the oak wilt pathogen. More than 12 beetle species are associated with oak wilt spore mats during the spring season in the North, but *Colopterus* and *Carpophilus* species are the most abundant.

Furthermore, only *Colopterus truncatus*, *Colopterus semitectus*, *Carpophilus sayi*, and *Epuraea corticina* are known to carry the oak wilt pathogen to fresh wounds during the critical spring period.

Spore mats can form only within a year after tree death, and only when air temperature and wood moisture are within a certain range. In the Northern United States, this combination of wood moisture and temperature commonly occurs in the spring of the year after the tree dies, or sometimes in autumn of the year the tree dies. As latitude decreases, the period of time during which mats form increases. In Texas, mats form at any time during the year, but most commonly in late fall and winter when the weather is cooler and wetter. In addition, spore mats are formed only on Texas red oak and blackjack oak, and never on Texas live oak. For this reason, red oak group species are important for establishing new infection centers in Texas. Spore mats usually do not form on trees smaller than 6 inches in diameter at breast height, although smaller trees can occasionally support mats. Across the range of oak wilt, most spore mats are produced on trees in the red oak group, but mats can also develop on bur oak. Mats do not form on other trees in the white oak group.

Another group of insects—oak bark beetles—can also carry spores of the oak wilt pathogen and help create new infection centers. These beetles acquire spores of the fungus just prior to emerging from oak wilt-killed trees and subsequently transmit them when feeding in the crowns of healthy oaks. The relative importance of these beetles as vectors of this disease varies by region. Oak bark beetles are considered minor vectors in the Central United States, but may be more important in the Appalachians.

Symptoms

Oak wilt disease symptoms progress differently in red oaks, white oaks, and Texas live oak.

Red Oak Group

Oak wilt is usually identified in red oaks by rapid leaf discoloration and wilting. Often the initial symptom is a subtle off-green color shift that may be visible in the upper portion of the tree crown. This symptom is apparent in the northern part of the disease range in late June to early July. Shortly after this initial color shift, the leaves begin to wilt from the top of the crown downward. As the disease progresses, individual leaves quickly discolor, taking on a bronzed appearance. The discoloration progresses around the margins of the leaf from the tip to the base (figure 7B). The progressing discoloration may be interrupted by the leaf veins, as shown in the white oak leaf in figure 7A, or may affect the entire upper portion of the leaf, as shown in the red oak leaf in figure 7B.

Leaves are cast rapidly as the infection progresses. Commonly, infected trees are almost entirely defoliated within a few weeks of symptom onset. Fallen leaves usually are brown at the tips and margins, and sometimes green at the base and along the lower veins. Trees are often killed in groups or disease centers, when infection occurs through grafted roots.

Occasionally the outer ring of vessels of diseased trees will be plugged with a brown substance that may be visible in cross sections as a ring or a series of dark spots through the outer sapwood, and in tangential cuts as longitudinal streaking of wood exposed after removing the bark. However, this is not always obvious to an untrained observer, especially in the red oaks.

The discoloration may be very light or appear as flecks in such sections. Discoloration is most readily seen in tangential cuts on branches.

White Oak Group

White oaks usually die slowly, one branch at a time, over a period of one to many years. Leaf wilting and death occur in a similar fashion to that of red oaks, but these symptoms usually progress much more slowly in white oaks. Affected leaves exhibit a pattern of discoloration similar to that seen in red oaks, with discoloration proceeding from the margins to the base, sometimes interrupted by the leaf veins (figure 7A). Brown streaking in the outer growth rings is often readily apparent even to an untrained observer in infected white oaks and bur oaks, but this symptom may also be missing.

Texas Live Oak

Texas live oaks can wilt and die rapidly or slowly, depending on the timing of infection and weather conditions. However, they generally succumb within 1-6 months of infection. Diagnostic leaf symptoms are usually produced somewhere on the tree (especially in spring and fall). Leaves develop yellow (**chlorotic**) veins that eventually turn brown (**necrotic**), a symptom termed **veinal necrosis** (figure 7C). Affected leaves fall, and the tree crown progressively thins out until the entire tree is dead. Fallen leaves under the tree may show darker brown veins for months. Sometimes just the tips, margins, or interveinal portions of leaves will turn yellow or brown, but these symptoms are not always the result of oak wilt and are not as useful in diagnosing the disease. A small percentage of Texas live oaks may survive oak wilt infection indefinitely while suffering varying degrees of crown loss.

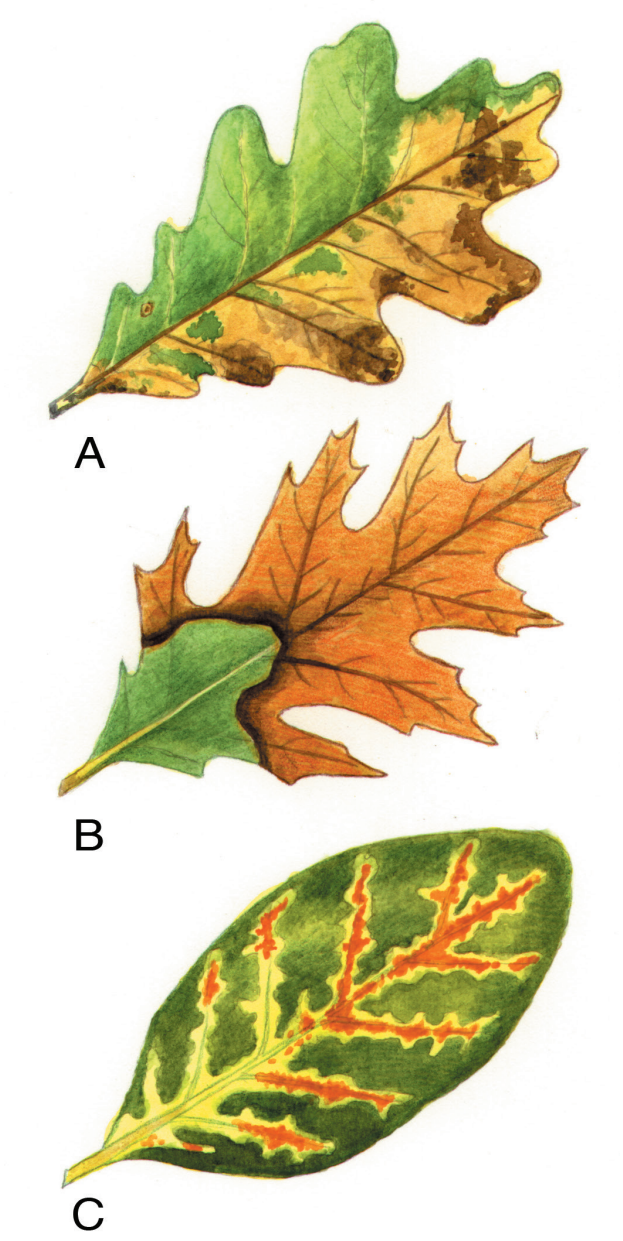

Figure 7.—Symptoms of oak wilt in A. white oak, B. red oak, and C. Texas live oak.

Diagnosis

Accurate diagnosis of oak wilt is essential before costly control efforts are begun. Foresters, arborists, or pathologists experienced with oak wilt can often diagnose the problem in the field using host species, symptoms, and mortality patterns. Properly sampling suspect trees and culturing the samples in a qualified laboratory may be necessary in some cases. See the publication "How to Collect Field Samples and Identify the Oak Wilt Fungus in the Laboratory" for additional information.

Other Disorders of Oaks

The following oak disorders may sometimes be confused with oak wilt: bacterial leaf scorch, anthracnose, decline, and infestation with twolined chestnut borer.

Bacterial Leaf scorch

Oaks in both the red and white oak groups are susceptible to a bacterial disease that causes leaf symptoms similar to oak wilt. Symptoms include marginal leaf browning, branch mortality, and eventually tree death. Trees may be symptomatic for several years before the tree dies, and symptoms usually persist on infected branches from year to year. While marginal browning is common, water soaking, bronzing, and wilting symptoms are absent, and trees do not die from bacterial leaf scorch very quickly.

Oak Anthracnose

Trees in both the red and white oak group are susceptible to a group of fungal leaf diseases collectively called **anthracnose** that may be locally severe if weather conditions in the spring are cool and wet for an extended period during leaf expansion, which favors development of

such diseases. Anthracnose diseases are usually more severe in the lower portions of the crown, often causing the affected leaves to fall in early summer. Leaves in the upper portion of the crown may remain attached. Leaf symptoms usually include brown spots or patches that expand outward to the leaf margins. Although the leaves may be curled and distorted, they usually do not wilt.

Oak Decline

Oaks throughout the Eastern and Southern United States are susceptible to a decline syndrome, which is defined as a disease caused by the interaction of several injurious agents working simultaneously. In the case of oak decline these factors can include drought, defoliation, fungi that cause stem cankers or root diseases, and wood-boring beetles. The interaction of these factors may result in the decline and death of oak trees in a local or regional area.

Oak decline symptoms vary greatly, and differentiating oak decline from oak wilt can be quite difficult. Indicators of oak decline include the absence of the typical leaf symptoms of oak wilt and the retention of dead leaves on the tree. Trees killed by oak wilt are usually completely defoliated and retain few living or dead leaves, but this may not be a consistent symptom for red oaks in the South.

Oak wilt usually occurs in discrete, spreading pockets of mortality, with trees on the margins of the infection center becoming infected over time. Declines may occur in discrete pockets, or over a fairly large area, but do not typically spread outward from an initial infection center. Trees in decline may die over a period of years, or may ultimately survive a decline episode with only dead branches in the crown.

Twolined Chestnut Borer

The twolined chestnut borer (*Agrilus bilineatus*) is an insect that attacks oaks, especially those weakened by drought or defoliation. Larvae of the insect make tunnels in the inner bark, causing branch or even tree mortality. Symptoms usually begin in the upper portion of the crown and proceed downward, but this pattern is variable. The insects leave a distinctive "D-shaped" exit hole about 1-2 mm in diameter when they mature and leave the tree. Initial symptoms are usually single or scattered dying branches that often retain brown leaves until autumn. This insect is often part of the oak decline syndrome mentioned above.

Integrated Management of Oak Wilt

Oak wilt can be managed with a variety of strategies that prevent new infection centers and limit the expansion of existing infection centers. A good management program for oak wilt will include all of these strategies for combating the disease.

Preventing New Infection Centers

Once an oak tree becomes infected with oak wilt, there is no known chemical treatment that is capable of "curing" the disease; however, fungicide research is continuing. The development of new oak wilt pockets can be avoided, however, by either preventing the development of spore mats of the fungus on diseased trees or by preventing the transfer of fungal spores to healthy trees. In practice this involves removing dead or diseased trees and avoiding injury to healthy trees.

Remove Infected Trees

Trees that are infected with or have died from oak wilt should be removed and properly treated to prevent development of spore mats. These treatments include debarking, chipping or splitting, and drying the wood. Covering dead wood with plastic, burying the edges for 6 months, and then air drying for a similar time will kill the fungus and any associated insects. Trees that die in summer should be removed and treated before the following spring, which is when new spore mats can develop. If the wood is sufficiently dried, however, spore mats will not develop.

⚠ **A word of caution**: Removing a diseased tree that is still living may actually facilitate the spread of the disease by accelerating the movement of the fungus into adjacent trees that are grafted to it by the roots. To avoid this problem, disrupt interconnected roots before removing living diseased trees as described in the section on "Controlling existing infection centers."

Avoid Injuring Healthy Trees

Freshly wounded trees that are growing outside of existing oak wilt centers can be visited by beetles transporting spores of the fungus. Because open wounds create avenues for infection, damage to trees from construction, pruning, or severe storms may lead to new infection centers. Avoid injury to oaks during favorable conditions for infection, which in the North occur in spring and early summer, when spore mats are present and the beetles are flying. Favorable conditions usually occur between April 15 and July 1 in the Lake States and over a correspondingly longer period of time to the south. In Texas, avoid damage to oak trees from February through June.

Preventing injury caused by human activity is especially effective in avoiding the establishment of new infection centers. In particular, pruning or construction activities in or near oak woodlots during the susceptible period often results in injury to oak trees that leads to infection.

If construction activity, tree removal, or pruning is unavoidable, or if storms injure oak trees during the critical period, the wounds should be treated with a commercial tree paint or wound dressing. If whole trees are removed during the critical period, the stumps should also be treated with tree paint. It is very important that the fresh wounds be treated immediately because the insects that carry spores of the pathogen are often attracted to these wounds within a very short time. Tree paints are normally not recommended for general use, but using these products in this situation can protect trees from oak wilt. In the North, tree paints are not necessary if trees are wounded during the dormant season; however, judicious use during the rest of the year is recommended. From Missouri to Texas, use tree paint immediately after trees are wounded at any time of the year.

Controlling Existing Infection Centers

Once the oak wilt fungus becomes established in a stand that includes a high proportion of oak, it will often continue to spread through the grafted root systems of the trees, infecting healthy oaks.

Disrupting the connections between the roots of infected and healthy trees limits the spread of oak wilt and is an effective control measure. Infected trees and their roots will usually die before root grafts can be re-established. The oak wilt fungus does not survive in the root systems of dead trees for more than a few years.

The potential for spread of oak wilt through grafted roots is especially high after a diseased

tree is removed or dies. While a diseased tree is still living and intact, there is some resistance to fungal spores moving through root grafts into the roots of healthy trees. The removal or death of a diseased tree removes this natural resistance to spore movement, and spores may then travel more freely through interconnected roots. Therefore, the timing of a root disruption treatment is critical. Roots should be disrupted before an infected tree dies or is removed, or within a short time of tree death, for maximum protection of healthy trees.

Interconnected root systems can be disrupted with a trencher, vibratory plow, or other equipment.

Trenching and Vibratory Plowing

Cutting roots with a trenching or cutting tool effectively controls the expansion of oak wilt pockets. In the Lake States, where deep and sandy or loamy soils are common, using a **vibratory plow** with a 5-foot blade (figure 8) is the preferred method of disrupting grafted root systems. The vibratory plow consists of a mechanical shaker unit with an attached blade that is pulled behind a tractor. The blade penetrates to a depth of about 5 feet, and cuts through the roots of oaks that may be grafted together. While oak roots may extend deeper than 5 feet in the soil, most root grafts are disrupted by trenching or plowing to that depth. Standard trenching tools do considerably more damage to the site, and the result is a much more apparent plow line than that caused by the vibratory plow. In Texas, shallow, rocky soils and even-layered rock often necessitate the use of a rock saw for disrupting oak roots. A chain trencher, backhoe, or ripper bar can sometimes be used. Trench depth should be about 5 feet, although this may be difficult to achieve in all situations.

Figure 8.—A vibratory plow is sometimes used to disrupt grafted roots to prevent local spread of oak wilt.

The lines cut by these trenching implements are usually referred to as **barrier lines** (figure 9). Successful disruption of root grafts to protect healthy trees close to an oak wilt infection center often requires that two or more parallel or intersecting lines be made. **Primary barrier lines** are those expected to have a good chance of protecting trees outside the lines. In addition, **secondary barrier lines** are often used to help ensure that the root graft disruption is effective. Separating groups of asymptomatic oaks from each other within the primary line may also save additional trees (figure 9).

Root graft disruption can be made even more effective by removing all oak trees inside the barrier lines following plowing or trenching. Removing these trees and optionally treating the stumps with an herbicide helps ensure that all of the oak roots inside the barrier will die before root grafts can be re-established. This practice is sometimes referred to as **cut to the line**. Although this is a radical treatment, it may be useful in areas where oak wilt eradication is the goal. Assume that all trees removed are infected with the oak wilt fungus and destroy or treat them on site.

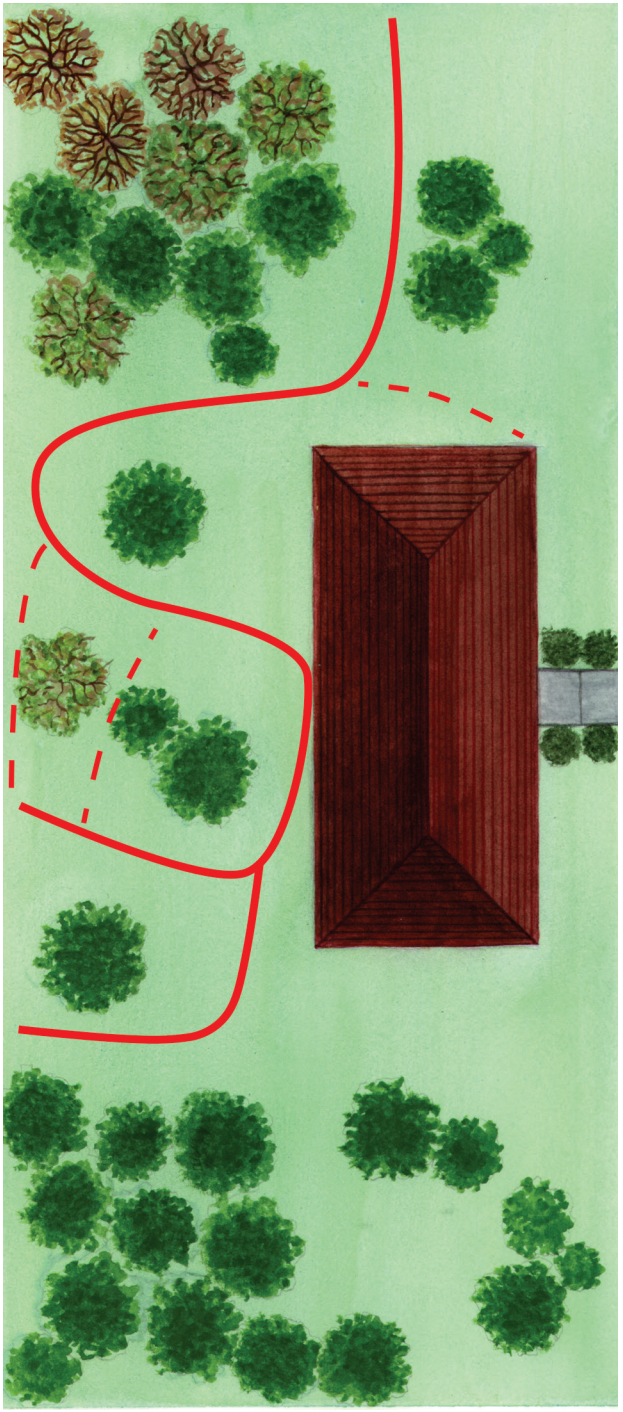

Figure 9.—This plan of a home landscape shows possible locations of vibratory plow lines for control of oak wilt. All trees are oaks. Brown trees are infected or dead; green trees are healthy. The solid red lines indicate primary barriers; the dashed lines are secondary barriers.

Stump Extraction as a Substitute for Trenching

In locations where the use of a vibratory plow or trencher is not practical because of infrastructure issues or boulder-laden soils, a strategy that involves cutting trees and uprooting the stumps may be a viable alternative. This procedure involves cutting all infected trees in an infection center as well as a buffer of nonsymptomatic trees around the infection center. Stumps of all cut trees are pulled from the ground using an excavator, which breaks many of the root connections between trees. Alternatively, trees and root systems can be pushed up and piled with a bulldozer. All cutting and stump extraction should be done during the dormant season.

This technique works best for new, smaller infection centers because the stumps can be removed before the fungus moves from the boles into the root systems of infected trees. It is also best suited to rural or forested areas where infrastructure is absent and drastic vegetative disturbance is more acceptable. If this technique is used, it is likely that followup treatments will be needed. However, this technique has proven effective where trenching or plowing is not feasible.

Chemical Root Disruption

Biocidal chemicals have been used in the past to disrupt root grafts in trees, including oaks. These chemicals are very dangerous and difficult to work with, but can sometimes be used in areas where vibratory plowing or trenching is not an option because of buried utilities and septic tanks, or steep slopes. Holes are drilled into the soil at prescribed intervals and the chemical is poured into the holes, where it diffuses into the soil and kills the roots in a localized area. These chemicals are restricted-use pesticides; they must be applied by a licensed pesticide applicator

who has been trained in their use. In addition, these chemicals are costly, may damage the trees, and are effective only in uniformly textured soils where chemical distribution is even and predictable.

Chemical Control Using Fungicides

Fungicides have been developed that may be effective in preventing oak wilt when injected into living oak trees without active symptoms. A single treatment can protect red oaks from developing symptoms for 2 years following injection. In Texas live oaks, such treatments have prevented mortality in many cases, although foliar thinning usually occurs and can be substantial. Use of these fungicides is warranted when infection of high-value trees via local spread through root systems is imminent. These fungicides are apparently unable to stop already infected live oaks and red oaks from dying. Those currently available utilize some form of a chemical called propiconazole in the formulation. Such treatments create their own problems, including the necessity of wounding the tree to inject the fungicides.

The cost of the fungicide is high, so only high-value trees should be considered for treatment. Contact your county extension office for current advice on the use of chemicals for control of oak wilt.

Summary of Integrated Oak Wilt Management Strategies

Effective oak wilt management programs use a variety of strategies to limit the spread of oak wilt. Some of the practices and policies that can be used in combination to effectively manage oak wilt include the following:

Avoid wounding oaks during critical infection periods.

- If pruning is necessary, or if wounds occur on oak trees during the critical infection period, apply tree wound dressings or paints as soon as possible to prevent transmission of oak wilt.
- Develop and enforce construction ordinances and utility pruning guidelines that minimize wounding of oak trees.
- Use public service announcements, billboards, and flyers to raise awareness of the dangers of wounding oaks during susceptible periods.

Use a vibratory plow line, trench barriers, stump extraction, or chemical disruption of roots to isolate pockets of oak wilt.

- Communities and neighbors should join together to lower the cost of these tools and achieve more complete and effective local control.
- Use root graft disruption, use cut-to-the-line practices, and treat stumps with herbicides to greatly reduce or eradicate oak wilt in local areas.

Remove and properly treat oaks killed by oak wilt by debarking, chipping, or splitting and drying the wood before the spring following the tree's death.

- Do not move infected wood offsite without debarking, chipping, or properly drying it. Do not move or store firewood from infected stands near healthy oaks without proper treatment.
- Use and enforce city codes and ordinances that mandate removal and treatment of dead oak trees. Such ordinances can significantly reduce the chances for overland transmission of oak wilt.

Use appropriate fungicides to protect very high-value trees at imminent risk of infection through root-to-root transmission.

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Glossary

Anthracnose

A group of fungal diseases that affect the leaves of many tree species. Anthracnose symptoms may be confused with those of oak wilt.

Chlorosis (chlorotic)

A loss of green color in leaves that results in a yellow discoloration.

Cut to the Line

The practice of removing all oaks, living or dead, inside the primary barrier line when using trenching to control local spread of oak wilt.

Infection Center

A localized group of trees that has been affected by a disease. The disease may spread from the margins of the infected group.

Local Spread

Spread of oak wilt from diseased to healthy trees through root-grafted, interconnected root systems.

Long-distance Spread

See Overland Spread

Necrosis (necrotic)

A brown discoloration of leaves that indicates dead tissue.

Nitidulid Beetles

Beetles in the family Nitidulidae, sometimes called sap beetles. These beetles have been determined to be the primary carriers of fungal spores of the oak wilt pathogen to healthy trees.

Overland Spread

Spread of oak wilt by nitidulid beetles from spore mats on infected trees to open wounds on healthy trees. Oak bark beetles can also help spread oak wilt.

Pressure Pad

See Spore Mat, Spore Pad

Primary Barrier Line

A trench cut to disrupt grafted roots of oak. If two lines are used, the primary barrier line is the one expected to have the better chance of protecting trees outside the line (see *Secondary Barrier Line*).

Root Graft

Roots that have grown together so that a graft union is made between the conducting tissues of both roots. The oak wilt pathogen can move through grafted roots between infected and healthy trees to cause new infections.

Secondary Barrier Line

A trench cut to disrupt grafted roots of oak. If two lines are used, the secondary barrier line is the one expected to have the lesser chance of protecting trees outside the line (see *Primary Barrier Line*).

Spore Mat, Spore Pad

A structure produced by the oak wilt fungus at the bark-wood interface of oaks killed by the disease. Development of the structure causes the bark to split, exposing the mat below. The mat is covered with the spores of the oak wilt pathogen, which are picked up by visiting nitidulid beetles.

Tyloses

Microscopic structures that are produced in the conducting vessels of white oaks, which block the movement of water and fungal spores within the tree. The rapid development of tyloses may explain the difference in susceptibility between white oaks and red oaks.

Vectors

Organisms (such as insects, mites, or nematodes) or higher animals (such as birds or rodents) that carry a pathogenic agent to a susceptible host.

Veinal Necrosis

Dark yellow or brown discoloration that occurs along the veins of leaves.

Vibratory Plow

A shaker unit with a 5-foot blade pulled behind a tractor that is used to disrupt the grafted root systems of oaks to prevent spread of oak wilt.

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